

Dennis (F. S.) ae/c.

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IN THE
TREATMENT OF COMPOUND FRACTURES

INCLUDING A REPORT OF
FIVE HUNDRED AND SIXTEEN CASES.

BY
FREDERIC S. DENNIS, M.D.,

PROFESSOR OF PRINCIPLES AND PRACTICE OF SURGERY IN THE BELLEVUE HOSPITAL
MEDICAL COLLEGE, ATTENDING SURGEON TO THE ST. VINCENT, NINETY-NINTH
STREET, AND BELLEVUE HOSPITALS, NEW YORK CITY.

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SOME POINTS OF SPECIAL INTEREST IN
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AT a meeting of the American Medical Association which convened in Washington, in June, 1884, I presented a paper on the treatment of compound fractures, in which were reported one hundred and forty-four cases treated consecutively, without a death from blood-poisoning. In the present contribution I shall present five hundred and sixteen cases of compound fractures, all of which, excluding those which were at that time reported, have occurred within the past two years in my hospital practice at St. Vincent, Ninety-ninth Street, and Bellevue hospitals. As many of these cases are of special interest from several points of view, I have undertaken the task of reporting them for the purpose of eliciting a discussion from members of this Association upon some important questions which naturally arise in connection with the general treatment of compound fractures. There are some recommendations discussed in my last paper which a larger experience

¹ Read before the New York County Medical Association, in the Carnegie Laboratory, October 18, 1886.

has taught me the wisdom of modifying to accord with more recent views in surgical pathology.

The procrustean rules of absolute cleanliness, of immediate fixation, and of provision for free drainage in every compound fracture, need no modification. The technique involved in carrying out the details of these rules may vary, but the general principles remain the same. A more extended experience in the treatment of compound fractures has taught me that, while absolute cleanliness is essential, and immediate fixation is necessary, that no splint should be left on a limb longer than eight days without either its entire removal, or at least an examination of the seat of fracture. Formerly I inclined rather to the view that a splint had better remain undisturbed throughout the entire period of repair; but within the past year I have seen several bad results arising from a too rigid adherence to this rule. In one case, I saw a compound fracture which was skilfully dressed with plaster of Paris examined at the expiration of six weeks, during which time the patient's condition was in every way satisfactory. Upon removal of the splint, the bone was protruding, the displacement was great, and considerable union had taken place. A complete osteotomy corrected the deformity, and six additional weeks were occupied in obtaining a result which was perfectly satisfactory. If this fracture had been examined at the end of eight days, the protrusion of the bone would have been detected at once, and the faulty position rectified. While this result is exceptional, such unfortunate complications can always be obviated by a simple inspection of the fracture after eight days, and then again in ten days, after which time no serious deviation can occur. The time involved in the careful examination of every compound frac-

ture is not to be considered in comparison with the risk which an omission to do so may involve.

Every compound fracture needs careful study and attention. I am more and more convinced of the importance of the first dressing. The patient who suffers from a severe compound fracture of any bone should be placed upon the operating table and the fracture examined and dressed with the same care with which a resected joint or a laparotomy should be dressed. The parts should be made aseptic at once, the deformity immediately overcome, the bones brought in exact apposition while the patient is under ether and the muscles are relaxed. Loose pieces of bone not adherent to periosteum are removed and the fragments are now adjusted, the antiseptic dressings applied with great care, a plaster-of-Paris bandage neatly placed upon the limb, and the fracture is certain to do well.

The manner in which the first dressing is applied has much to do with the prognosis. Esmarch has said that the fate of a patient often hangs upon the surgeon who first touches the wounded man. Wherever the circumstances are within the control of the surgeon, I would go even still further and recommend that ambulance surgeons should exercise great care in the transfer of a compound fracture to the hospital. I have made it a rule of practice at the Ninety-ninth Street Hospital that antiseptic irrigation should be employed at the station-house or upon the sidewalk before the patient is moved, and that at once after the irrigation a clean antiseptic dressing be applied before the patient is lifted into the ambulance. I feel sure that the success of treatment in the large number of compound fractures which have been admitted to this hospital is in great part due to the strict adherence of this im-

portant rule, which I have found willingly and cheerfully obeyed by the ambulance surgeons, who have begun to realize how important is their position in the matter of antiseptics.

There are some new questions which have arisen that are of interest when discussed in the light of the recent revelations in modern surgical pathology. Among these many subjects for special study and observation I have selected a few which seem to me as possessing unusual interest in connection with the report of these compound fractures.

1st. Meningeal hemorrhage.

2d. Fat embolism.

3d. Insanity following fracture of skull.

4th. Malignant disease.

5th. Tenotomy.

6th. Healing by Schede's method.

7th. Amputation.

Meningeal Hemorrhage.—This variety of hemorrhage occurring in compound fractures of the skull has been a subject about which there existed much diversity of opinion among surgeons. It has been the routine treatment for many years to ligate the common or the external carotid artery in case of severe hemorrhage from the middle meningeal artery or one of its large branches. I have ligated the carotid in a case of severe meningeal hemorrhage and the bleeding was at once arrested. Among the cases in my list of compound fractures of the skull is one which is of great practical interest as bearing upon a new method of arresting hemorrhage without resorting to a ligation of the carotid.

In the case referred to, a man received a severe compound fracture of the skull upon the right side. The accident was caused by a stone weighing 700 pounds falling upon his skull. I trephined the seat

of fracture and removed over forty pieces of bone, loose in the wound, of which two fragments were larger than a twenty-five cent piece.. I found a large epidural blood-clot nearly the size of the palm of my hand between the dura and the internal surface of the skull. I removed the blood-clot, which I have preserved as far as possible in this glass jar, and upon the removal of the blood-clots I found the middle meningeal artery bleeding to an alarming extent. I controlled the hemorrhage as best I could temporarily with sponges and tampon until I was enabled to remove more bone in order to secure the open vessel. Having removed bone to the extent of six inches I attempted with artery forceps to seize the bleeding point. Every attempt failed and I was unable to grasp the artery on account of the dura mater receding when the artery forceps caught hold of the depressed dura mater through the opening in the skull. Whenever the ends of the forceps were applied to the dura mater this membrane was pushed down and the forceps could not be made to catch hold of the bleeding point.

The idea suggested itself to me in this crisis to introduce the point of a tenaculum through the membrane and out again in such a way as to include the bleeding vessel in the curve of the tenaculum. With this instrument I now raised up the dura mater from the brain on a level with the skull, and then applied the artery forceps. The dura mater, which before receded from the grasp of the forceps, and formed a tense, concave surface, was now held firmly, and that part of the membrane held between the curve of the tenaculum was lax, and permitted the forceps to seize tissue and artery. The vessel was tied with catgut, and the hemorrhage was arrested.

The paralysis upon the left side of the body disappeared. The wound healed in an aseptic manner, and the patient recovered so far as the operation was concerned. He died some four or five weeks after the injury, and I was enabled to secure an autopsy, which was made by Dr. Grauer. There was nothing in the brain, or in its coverings, which could have caused death; the patient had died from exhaustion and inanition, with no local brain lesion. The use of the tenaculum in the manner described, to seize a torn middle meningeal artery through an opening made in the skull, seems to me a better operation than ligation of the external or common carotid artery in the continuity.

Besides the question of the arrest of hemorrhage by ligation of the meningeal artery by means of a tenaculum introduced through an opening in the skull, another question has arisen in connection with these cases of meningeal hemorrhage. The possibility of a surface clot by contre-coup has been denied by many surgeons. I have here two specimens which I believe will settle this long-disputed question.

In the first of these cases, a patient was found by a policeman on the street, at eight o'clock in the evening, in a condition of what was supposed intoxication. He walked to the station-house, and was locked up for the night, and at ten o'clock the following morning he was brought before the police justice in court, and was sentenced to ten days for intoxication. At eleven o'clock he was returned to the station-house, awaiting the time to be sent to the Island. While in the cell, a few minutes after his arrival, he became unconscious, an ambulance was summoned, and he was taken by Dr. Rau to the Ninety-ninth Street Hospital. I saw the patient

that day, and from the history of the injury and the paralysis, I diagnosed meningeal hemorrhage. The patient was anæsthetized and the uninjured scalp was incised, exposing to view a linear fracture. The trephine was applied, and a large epidural clot was discovered. The dura mater was torn, and the brain substance lacerated. The wound was dressed antiseptically. In fourteen hours the patient died. The autopsy revealed the presence of a second epidural clot which was almost opposite, and was the result of contre-coup. The scalp over the skull corresponding to this clot was normal as upon the opposite side.

The second case was also seen by Dr. Rau, the house surgeon of Ninety-ninth Street Hospital. The patient was brought to the hospital in an unconscious condition with general paralysis. The case was supposed to be a fracture at the base of the skull. The patient died the next day, and the autopsy showed a linear fracture of the parietal bone upon one side, and extending to the middle fossa, under which fracture was a large epidural clot, and upon removing the calvarium another surface clot was found at a point directly opposite to the fracture. This fracture did not extend upon the other side of the skull, and the clot here was also the result of an injury by contre-coup.

These two specimens settle the important question whether a meningeal hemorrhage may be produced by contre-coup. The diagnostic points of epidural meningeal hemorrhage by contre-coup, or by traumatism without fracture, suggest operative interference in these cases.

The presence of symptoms of cerebral irritation, followed by unilateral paralysis, with a slow tense pulse, the Cheyne-Stokes respiration, accompanied

by a sudden rise of the temperature due to disturbance of the heat centre, form a group of symptoms, which, if they were preceded by a short interval after the injury in which no serious manifestations of brain lesion were present, make it extremely probable that an intracranial meningeal hemorrhage had occurred.

This group of symptoms appearing at the time, and in the order mentioned, with or without any fracture, would indicate the application of the trephine over the seat of pressure, the removal of the clot, and the ligation of the middle meningeal artery through the opening made in the skull by means of a tenaculum applied in the manner already described. To some this may seem too bold; but when the fact is considered that it has been demonstrated that formerly nine-tenths of these cases perished under the expectant plan of treatment, and when further it is considered how safe the operation of trephining is in the hands of antiseptic surgeons, it would seem that a surgeon might be derelict in his duty if he did not resect a portion of the skull and remove the clot and arrest the bleeding. I have applied this principle in several cases with success where I trephined in head injuries, suspecting, but having no knowledge of a fracture of the internal table, and have removed many pieces from the inner surface of the skull.

Fat Embolism.—This interesting complication in the treatment of fractures in general was first described fully by Wagner and Zenker. Fat embolism means the entrance of fluid fat probably derived from the medulla of the bone into the veins in the immediate vicinity of the fracture, and through these channels into the capillaries of the brain, spinal cord, lungs, kidneys, and other essential organs.

The presence of fluid fat in the blood had been described as early as 1836 by Dr. R. W. Smith; but the clinical importance of this symptom was not investigated until recently by Bergman, Czerny, and Scriba. Déjérine has experimentally produced in the lower animals fat embolism by inserting laminaria-tents into the medullary cavity of the long bones. The occurrence of fat embolism in fractures is undoubtedly much more frequent than has been formerly supposed, and without doubt, also, the dangers of this condition have been over-estimated. Fat embolism has been fatal in laceration of the liver where the patient had a fatty liver, as in alcoholic or in tuberculous patients; but these cases are altogether different from the fat embolism which is found in connection with a fracture. Flournoy pointed out three essential conditions necessary to the development of this complication. He demonstrated that there must exist large openings in the veins, free fluid fat, and a *vis a tergo*, which is found in copious extravasations of blood.

The symptoms of fat embolism appear within the first three days as a rule, and consist of those of secondary shock. They occur before the time at which venous thrombosis or pulmonary embolism would be expected to arise. Great dyspnœa associated with the Cheyne-Stokes respiration, and great irregularity of the heart with a sudden rise of temperature, together with twitchings of the muscles, as well as paralysis of certain muscles, have been observed in these cases. There have been no metastatic abscesses found in the cases of fat embolism where a report of the autopsy has been published. In several cases I have been able to find an abundance of fat globules in the urine following a train of symptoms such as has been mentioned.

I have seen these symptoms appear after osteotomy where the condition of the wound itself was perfect. Fat embolism is said to be found more frequently in fractures in the aged, because the medulla contains much fat, and not often in children, owing to absence of fat in the medulla.

The treatment which has been recommended in this condition, with a view of dissolving the fat, is the administration of ether, and also a free use of the diffusible stimulants. In cases of cyanosis with great dyspnoea, artificial respiration has been suggested. I have never seen a case of fat embolism where it became necessary to resort to these severe measures, but the attacks have been of short duration, and have been followed by the presence of fat in the urine. In pathological specimens, osmic acid stains the tissues so that the fat appears in black globules of irregular shape, but in the urine the fat globules are detected by the microscope.

I have at present under treatment, in Bellevue Hospital, a case of simple fracture of the fibula, in which the complication of fat embolism has arisen. On the 5th of October the patient sustained a fracture of the fibula, and upon admittance to the ward was in good condition. Two days later she suddenly developed a temperature of $104\frac{1}{2}^{\circ}$ F., associated with vomiting and diarrhoea. Her pulse was rapid and feeble. The urine, which upon admittance was normal, now became bloody, contained casts, and was loaded with fat globules. The examination of the urine was made by Dr. Houghton, who exercised great care in the investigation. The patient grew better under treatment with Hoffmann's anodyne and ammonium carbonate, and her condition now is in every way satisfactory.

This group of symptoms must not be mistaken for shock following a fracture, nor for pulmonary embolism. The former condition may be said to be present three hours after the fracture, fat embolism three days after the fracture, and pulmonary embolism three weeks after the fracture. For convenience, I have arranged these complications in the order in which they are most likely to occur, and by associating these conditions which simulate each other by the time in which they appear, no mistake in diagnosis is likely to arise.

Insanity following Fracture.—There have been a good many cases of insanity following traumatism of the head, and this is a generally accepted view among specialists in nervous diseases. To trace the etiology of insanity to a fracture of the skull is more difficult. I have now a patient in an asylum as a result of a fracture of the skull, and I understand that he is hopelessly insane. I have under observation, also, a case of imbecility and idiocy which resulted from a pistol-shot wound of the skull. In another case of severe and persistent headache extending over a period of six years, I trephined over the site of a previous fracture, and found the dura thickened and the seat of a pachymeningitis. The removal of the depressed bone relieved the intracranial pressure, and the patient—whom I now see from time to time—has never had any return of the agonizing pain in her head, and her mental condition seems much improved. This patient is now at work, and expresses herself as perfectly well.

In three cases of traumatic epilepsy attended with more or less mental disturbance I have used the trephine with most excellent results. I am aware that, as a rule, trephining is not uniformly successful in epilepsy, and my own experience has

led me to expect little from the operation in those cases where there is not a well-marked depression produced by a fracture.

There is a case reported recently by Dr. McDonald, in which insanity followed a compound fracture of the skull, and where the patient recovered completely after an operation. The depression in this case was situated over the first frontal gyrus marked 12 by Ferrier. There is also a case reported by Dr. McEwen, of Glasgow, where insanity was produced by a fracture of the skull with depression, and where the patient recovered after trephining. Schroeter mentions a case where a patient became insane on account of a fracture of the skull. Dr. Spitzka was kind enough to show me in his collection several interesting specimens bearing upon this point. One specimen was part of a brain belonging to a patient who was struck by a fragment of a shell at Chancellerville. He became insane and died after some time. The injury was in the median line, the dura was thickened and adherent, and there was milky opacity. The lepto-meninges were thickened, the sulci beneath gaped, and the perivascular spaces were enlarged. Dr. Spitzka also gave me the notes of another patient who became insane after a depressed fracture of the skull produced by the explosion of a shell at the battle of Bull Run. At the autopsy there was found periencephalitis corresponding to the indentation upon the inner surface of the skull. The dura was universally adherent on both hemispheres, and there were hæmatomatous efflorescences in both dural sacs. In another case where a patient had been kicked by a horse on the left frontal region over the superciliary ridge, the depression internally was an exaggeration of the mamillary eminences, and they stood forth like

spiculæ of bone. The hemispheres were unsymmetrical, and a well-marked depression was seen upon the frontal lobe beneath the seat of fracture.

Many other cases might be found where the cause of insanity is due to an old and unrelieved depressed fracture. In all these cases depression existed, hence the important point of elevating at the time of accident, even though no symptoms exist. A study of these cases shows clearly that insanity may result if a depression is left in the skull in a recent injury, and when it is demonstrated how free from danger is trephining in careful hands, and what serious conditions may follow neglect to perform this operation, it seems clearly evident that in every case of marked depressed fracture, with or without symptoms, the surgeon should elevate the bone for fear that some form of mental disturbance may follow.

The kind of insanity which follows in these traumatic cases is that form which is attended with great irritability and mental excitement, and which is also accompanied with fits of violent temper and passion. These phenomena are suggestive in depressed fracture, and call for surgical interference in a class of cases where, until recently, no relief could be extended to the sufferers.

Malignant Disease.—The question of development of malignant tumors at the seat of fracture is an exceedingly important one in surgical pathology. Gross, of Philadelphia, has pointed out the important fact that almost half of the cases of malignant bone disease can be traced to traumatism. His valuable contribution upon this point is worthy of careful study. I have been able to verify in my own experience the conclusions which Gross draws from a study of a large number of his own cases.

During the last month I operated upon a child with an immense sarcoma developed upon the occiput. The child sustained a heavy fall upon the back of the head six months previous and a large hæmatoma was at once developed. The hæmatoma was not incised and in all probability a linear fracture existed beneath it. For some weeks after the injury there was nothing special except the presence of the hæmatoma; but the tumor then began to grow very rapidly and in less than six months from the receipt of the injury the sarcoma was much larger than the child's head. The patient died some weeks after an incomplete operation for its removal. No autopsy was permitted; but at the time of the operation I found the skull perforated and the brain exposed. The tumor was examined by Dr. McNamara, who pronounced it to be a sarcoma. The history of the case and the nature of the fall, make it extremely probable that a linear fracture existed and from this point the malignant disease took its origin.

I have here a beautiful specimen illustrating the clinical fact that a fracture may be the starting-point of sarcoma. The patient from whom this thigh was removed was treated by Dr. Robb for a fracture of the femur just above the condyles. Some six months after the accident a rapidly growing sarcoma developed at the seat of fracture. Dr. Robb sent the patient to me for an amputation at the hip-joint. The patient would not, for a long time, consent to the operation, and when he finally acceded the tumor had made great progress and had seriously affected his general health. He did not survive the operation, but died within twenty-four hours.

I have had a large number of cases of malignant

disease which could be traced to traumatism ; but to trace the traumatism directly to a fracture of the bone is not a common occurrence.

The variety of tumor which develops is sarcoma, as carcinoma is, as a rule, a metastatic disease in bone. True sarcomata may be central—that is, growing from the cancellous tissue of the medullary canal of the bone ; or else periosteal, in which case the starting-point is from the covering of the bone. These tumors grow very rapidly, and soon infect the patient.

The prognosis, while grave, is not necessarily fatal provided the tumor is recognized early and the operation is performed far from the seat of disease. This subject of the influence of fracture upon the development of sarcoma is one to which no extensive investigation has as yet been made and it is one which offers a rich field for original research.

Epithelioma also may develop indirectly as a result of a compound fracture ; but this malignant growth has its origin from the soft tissues in connection with a sinus leading down to necrosed bone. If a sinus is not healed it becomes lined with epithelium and a discharge of ichorous pus through it from time to time sets up an irritation in the epithelial-lined sinus and a proliferation of epithelial cells takes place and epithelioma may in this way secondarily develop. While the epithelioma is not directly in connection with the seat of fracture as is the case in sarcoma, nevertheless the disease may have its origin in conditions arising from sequestration in a compound fracture. The closure of such sinuses in connection with necrosis following a fracture should always be aimed at by the surgeon. Early amputation before glandular enlargement at a

point distant from the disease may offer a favorable prognosis.

Tenotomy.—Two years ago I called attention to this procedure in the treatment of compound fractures, and in a number of cases since then I have been impressed with the value of this operation in all oblique compound fractures where the fragments overlap. Division of the tendo Achillis relieves at once any contraction of the muscles, permits the fragments to be placed accurately in coaptation, and the physiological rest thus secured affords great comfort to the patient, and a valuable means of fixation to the fracture during the first ten days. The tenotomy in no way increases danger to the patient, and is easily performed. The foot should be placed in its normal position, as recommended in Dr. Reginald Sayre's most excellent monograph upon fixation of the foot, immediately after tenotomy for club-foot.

The operation is not limited to the tendo Achillis, but may be employed with advantage in exceptional cases upon the hamstrings, in fractures of the tibia or fibula close to the knee-joint. It may also be found a most valuable adjuvant after osteotomy in the anterior curvature. The same may be said in reference to the tendons of the arm and forearm, and even in fractures of the clavicle, if the clavicular origin of the sterno-cleido-mastoid muscle tends to pull the inner fragment upward and away from the outer fragment. I believe there is much to be gained by the adoption of this simple device in the treatment of many cases of compound fracture of the extremities where there is difficulty in reduction, and from the excellent results obtained in those fractures where this procedure was resorted to I can commend it as a most valuable measure.

In vertical fracture tenotomy is of no avail ; but in several cases of compound fracture of the tibia, where the solution was parallel with the long axis of the bone, with considerable separation of the halves, I have found great difficulty in bringing the two long vertical fragments in contact. The Signourini horseshoe tourniquet proved a most valuable instrument in closing the long fissure. The instrument overcomes the vertical separation just as tenotomy overcomes the oblique displacement. The pad can be applied to one side of the bone, and pressure can be made by applying the other pad over a thick plaster bandage. The screw can be tightened gradually, and in a few days the bone can be approximated, and the instrument discarded. This is a safe and more satisfactory instrument than the apparatus devised by Malgaigne.

Healing by Schede's Method.—In a number of severe cases of compound fractures of the leg and skull I have observed some beautiful illustrations of this newly described method of repair. In a recent paper read before the German Congress of Surgeons this subject was ably discussed by Schede, and the views which he enunciated are somewhat at variance with the generally accepted opinions upon this pathological question. It has usually been taught that blood-clots in wounds are obstacles to repair by primary intention, and that these clots act as foreign bodies. In one case of severe compound fracture of the leg there was great hemorrhage between the fragments, and a large space left between them, which was filled with fluid blood and blood-clots. I divided the tendo Achillis to counteract the contraction of the muscle, and also in order to bring the fragments in better apposition. The leg was then dressed with the most rigid aseptic precautions, and

the blood-clots became organized and furnished a most valuable medium of union. The fracture healed by primary intention, and the patient made a most excellent recovery.

Fluid blood and blood-clots, if perfectly aseptic, are valuable adjuvants in the repair of compound fractures. They are, however, most potent sources of evil if any possible infection reaches the clot through any carelessness of the surgeon. It is a most valuable contribution to the treatment of compound fractures, if the blood which escapes between the ends of the fragments can be in the future utilized as a means of hastening and perfecting union by primary intention. The reason why so important a principle in surgical pathology has been so long unknown is explained by the fact that blood-clots, until rigid asepsis was established, were recognized sources of septic inflammation. If all the surrounding parts in every compound fracture are made aseptic, blood-clots and fluid blood can be utilized for the purpose of healing. Anything short of surgical cleanliness will convert these clots and the blood into dangerous agents of infection.

Amputation.—Amputation of the member in compound fracture was resorted to formerly with great frequency in hospital practice. Until the introduction of reliable and scientific antiseptics, pyæmia destroyed the life of almost every patient suffering from compound fracture who was brought to a large metropolitan hospital. The time is within my own recollection when amputation was immediately performed as routine treatment in Bellevue Hospital upon the admittance of a severe compound fracture to prevent blood poisoning; and this operation was considered by surgeons as offering to the patient the best chance of recovery. At the present

time limbs are saved which were then sacrificed, and it is a rare event to witness an amputation in compound fracture. Extensive fracture of the bone with protrusion of the fragments through the soft structures would not now form an indication for amputation, unless the soft structures were badly lacerated.

A fracture into the ankle- or knee-joint was, until recently, considered an injury requiring amputation ; but now the joint is washed out and provided with free drainage, and the fracture repairs, and the function of the joint is fully restored. I have recently treated a case of compound fracture and dislocation into ankle-joint, with protrusion of astragalus out of the wound. This bone was returned to its proper place, and free drainage was afforded after irrigation of the joint. The joint was perfect in all its movements after a fortnight. I have two cases now under treatment, but it is too soon to predict as to the function of the joints. Formerly the loss of a few inches of the shaft of the bone called for primary amputation. This no longer offers an indication, for the bones are brought together by silver wire, and though the limb may be shorter than the opposite one, the member is still retained and elevation of the shoe compensates for any slight irregularity in the gait. In one case which I treated where four inches of the tibia were removed, the patient made an excellent recovery, and to-day has better leg than any artificial one. In this box is the piece of the shaft which was removed from the patient to whom reference has just been made.

The limits to which amputation in compound fracture may be resorted to, are exceedingly narrow and restricted, and this conspicuous clinical fact is one of the most notable steps in the march and advance of modern and conservative surgery.

Another important point in reference to an amputation in compound fracture is the proper line of treatment to be pursued up to the time of the operation. It often happens that a patient is suffering too profoundly from shock to make it expedient to operate. In these cases I have found great benefit to be derived from deferring the amputation, even several days, until the condition was such as to justify the operation. Formerly this could not be done without subjecting the patient to a greater risk from septic infection than would be incurred in an amputation during shock. If the wound is made at once aseptic and compresses be placed over the fracture to control the hemorrhage, and these compresses do not extend any higher than the wound itself, the amputation can be deferred. It is important that these compresses be applied only over the wound, and that no form of compress or bandage be applied to the limb above the injured part, for if this is done there is danger of dry gangrene in the flaps above the wound. In one case this accident occurred from a neglect of this rule, though the compression was made before the patient was brought to the hospital, and in no way could any neglect be attached to the hospital authorities.

The complete history of the five hundred and sixteen cases of compound fractures I have here before me on this table for inspection and examination. Each case is given in full with the name of the patient, the date of his or her admittance to the hospital, the age, a description of the injury, the treatment in full, and the result. I have also here in this large roll of papers most of the temperature charts. In these glass bottles are the pieces of skull which have been preserved, and are labelled to correspond to the cases given in the table. Upon this

table are the bones of the leg, thigh, arms, and forearm in which amputation was performed, also the pieces of bones from the joints, which pieces were removed by resection. I have preserved these specimens with great care. It is obvious that time will not permit the reading of these histories, amounting to 516 in all, and therefore I can only give a summary which will include them all. I would state, however, that anyone desiring to take the time is at liberty to examine each case.¹

The list of compound fractures of the *skull* contains 107 cases, 68 of which recovered and 39 of which died; 31 of the fatal cases died within 48 hours after the receipt of the injury. Of the remaining 8 cases, 1 died one month after the operation of trephining from exhaustion and inanition, with the wound healed. The autopsy, which was made by Dr. Grauer, showed nothing in the brain to account for the death. Of the remaining 7 cases, 3 died from cerebral softening, as in apoplexy, disconnected with the original wound, and 2 cases from irreparable damage to the brain, one being extensive cerebral laceration due to the lock of a gun driven through the skull, the other being a fracture at the base of the skull. The remaining case died in 52 hours from lepto-meningitis following the operation of trephining, in which the dura mater was found injured.

The list of compound fractures of the *arm* contains 15 cases, 14 of which recovered and 1 died. The fatal case was a railroad injury, with great crushing

¹ [The full history of these cases, in tabular form, accompanied this paper, but we regret that the large amount of space which they would occupy precludes their publication in THE NEWS.—EDITOR.]

of the parts, and the patient died in 48 hours, having never rallied from shock.

The list of compound fractures of the *forearm* contains 23 cases, of which 22 recovered and 1 died. This fatal case, which was complicated with extensive burns, never rallied from shock and expired within 24 hours.

The list of compound fractures of the *thigh* contains 53 cases, of which 48 recovered and 5 died. In the fatal cases death occurred within 48 hours.

The list of compound fractures of the leg contains 150 cases, of which 15 required primary amputation; of the remaining 135 cases, 125 recovered, 2 were transferred at their own request from hospital immediately after admittance, and 8 died, and none of these 8 fatal cases survived forty-eight hours.

The list of compound fractures of the bones of the *hand and foot* shows 37 cases. Many of these cases of compound fracture were complicated with great laceration and crushing of the soft tissues. These injuries were caused by heavy weights falling upon the hand or foot, or by circular saw or railway accidents. In many cases the damage to the soft parts was very great. The joints were opened, the tendons exposed, the soft parts crushed, and the tissues generally torn and lacerated. These cases all recovered, with the exception of one which terminated fatally from other injuries and to which reference will be made later.

The table of compound fractures involving the *shoulder-, elbow-, and wrist-joints*, contains 23 cases, all of which recovered.

The table of compound fractures involving the *hip-, knee-, and ankle-joints* contains 43 cases, 4 of which required primary amputation, and 3 of which were fatal. Of the three fatal cases one died of

tuberculous meningitis some weeks after a resection of the hip joint, another died within twenty-four hours from shock, and the third died a week after wiring of the patella from Bright's disease which caused uræmia. The joint wound was aseptic. In none of the three fatal cases involving these major joints could septic infection have been a cause of death.

The table of compound fractures involving the *carpal and metacarpal and the tarsal and the metatarsal joints* contains twenty-four cases, all of which recovered.

The table of compound fractures of the *upper and lower jaws* contains 28 cases, 4 of which were fractures requiring suture by silver wire, and all of which recovered.

The table of compound fractures of the *ribs and nasal bones* contains thirteen cases, twelve of which recovered ; the one fatal case was that of a patient who received a compound comminuted fracture of all the bones of the face and some of the skull, the result of the fall of a heavy derrick upon his head. The patient died in thirty-six hours.

The table of compound fractures of the *ilium and the malar bones* contains three cases, one of the ilium and two of the malar bones, all of which recovered.

A final summary of all of these cases of compound fractures of the different bones of the body is as follows :

Skull	107
Arm	15
Forearm	23
Thigh	53
Leg	150
Fingers and toes	37
Fractures involving shoulder-, elbow-, and wrist-joints, result of accident or of operation	23
Fractures involving hip, knee, and ankle joints	40
Fractures involving carpal and metacarpal, tarsal and metatarsal joints	24
Superior and inferior maxillary bones	28
Ribs and nasal bones	13
Compound fractures of the ilium and malar bones	3
Total	516

In this total of 516 cases of compound fractures, produced by traumatism or by operation, there were 59 deaths, 19 primary amputations, and 2 cases where the result was unknown on account of the removal of the patients, at their own request, from the hospital immediately after their admittance. In the 59 fatal cases, 49 died within forty-eight hours after the accident and during shock, and consequently these deaths should not be included in any figures to ascertain the percentage of mortality, because the patients died before any plan of treatment could be adopted having reference to the repair of the fracture, or to the prevention of septic infection.

The remaining ten deaths occurred in the following manner: one from tuberculous meningitis following some weeks after a resection of the hip-joint, so that this case died from other causes than septic infection; another patient died from uræmia in chronic Bright's disease one week after wiring the patella, and the wound was aseptic, so that this case died from other causes than septic infection; another case died one month after trephining from exhaustion and inanition, with the wound perfectly healed

by primary intention, and at the autopsy with no evidences in the brain of pathological changes indicating sepsis as the cause of death, so that death in this case cannot be attributed to septic infection; two other cases died from irreparable damage to the brain, in one of which a lock of a gun was driven through the skull into the brain, and in the other a fracture at the base was found at the autopsy in addition to the fracture of the parietal bone, so that death in neither of these two cases was due to pyæmia or septicæmia; three other cases died from cerebral softening which was situated at a distance from the original wound.

In reference to these cases of cerebral softening, following the injury, a word of explanation seems pertinent. These circumscribed areas of softening in every respect resembled the changes which are found after apoplexy. There was no local evidence of septic infection, and in all the three cases the autopsies were made by experienced pathologists, who coincided in this opinion. The situation of the softened areas at a point distant from the original wound, and the changes—*i. e.*, hemorrhage and softening, the perfect aseptic and healed condition of the external wounds, which are identical with those found in cerebral apoplexy—indicate that these three cases are not of septic origin from the wound.

The cerebral softening appears to be due to a molecular disintegration or laceration of brain tissue from traumatism, and this disturbance of the nutrition produces a metamorphosis and the liquefaction takes place. The external surface of the dura mater seems to possess power to prevent the entrance of septic microorganisms into the cerebral substance; while the internal surface of the dura mater, owing to its proximity to the arachnoid space, is exceedingly

delicate and susceptible to the slightest influence of any septic material. Experimental work in this direction indicates that such points of softening may have their origin in traumatism and not necessarily be due to sepsis. I believe that these three cases are explained in this way, and therefore these cases may be eliminated from the list of deaths due to septic infection derived from the wound in the skull.

I feel certain that these softenings were not the result of infection from the wounds; because the wounds were aseptic. To convince myself further of the accuracy of this conclusion I trephined the skull of a dog and planted upon its dura mater septic micrococci, which were furnished to me from cultures belonging to Dr. Biggs. Though the microorganisms were septic, they were incapable of developing a cerebral abscess through the dura mater or even producing a meningitis.

Such an experiment, while it is not conclusive, of course carries additional evidence in favor of the non-septic origin of such cerebral softenings, though they may be due to the presence of some such microorganisms as bacilli tuberculosis; but at the same time the traumatism may have acted as an exciting cause to develop an abscess in tissue already impregnated with a pathogenic germ. This explanation places a higher value upon antiseptic surgery, and it serves also to illustrate at the same time that an operation like trephining may be a brilliant success so far as the operation is concerned; but yet the patient perishes from causes which are as yet beyond the complete control of the surgeon.

There is still an unoccupied field for further investigation and research in this domain of surgery, and surgeons must turn the direction of their studies to those causes of death which are not connected

with the details of antiseptic surgery. Perfection has been almost reached in the technique of the operation of trephining, but as yet there are circumstances which are not controlled by the practical surgeon and to a study of these causes future scientific surgery must engage.

Finally, to refer to the two remaining deaths, which may be fairly considered as septic. One of these cases died from lepto-meningitis fifty-two hours after the trephining, and the last case in ninety hours after a crushing of the foot, in a patient over sixty years of age. This makes only two deaths which could be ascribed to septic infection.

Deducting from the original 516 cases the 49 cases which terminated fatally within forty-eight hours, and the 19 cases which required primary amputation, also the 2 cases which were immediately transferred at their own request from the hospital, there remain 446 consecutive cases of compound fractures, with only 2 deaths. This shows a rate of mortality of less than one-half of one per cent. If now the 61 cases of compound fracture of the bones of the hands and feet be excluded as too insignificant, in accordance with the custom among all surgeons in their statistical reports of compound fractures, there still remain 385 consecutive cases of compound fractures, including, to the best of my knowledge, every case which has come under my treatment, with but one death, which gives a still less percentage of mortality, which is less than one-third of one per cent.

In order to appreciate what progress surgery has made during the last half century in the treatment of compound fractures, it is interesting to examine hospital reports embracing this period. Before the

introduction of antiseptics the best statistical reports of compound fractures are those of Norris. He showed that in the Pennsylvania Hospital, between the years 1839-1851, there were treated 116 cases of compound fractures of the leg and thigh (excluding those cases requiring amputation), with 51 deaths, thus giving a rate of mortality of 44 per cent. This is only an approximation, as the table does not state whether any amputations were primary or secondary. In the New York Hospital, during the same period, there were treated 126 cases of compound fractures of the leg and thigh (excluding those cases requiring amputation), with 61 deaths, thus giving a rate of mortality of 48 per cent. The previous remark also applies to this percentage, but in neither case would the percentage be notably decreased.

A decade later, from 1860-1876, there were reported from the surgical clinics of Vienna and Zurich, by Billroth, 180 cases of compound fractures. Excluding those cases of amputation, there is a mortality of 31 per cent. from septic pyæmia. In the Obukow Hospital Reports of St. Petersburg there are reported 106 cases of compound fracture, with a mortality of 68 per cent. No particulars are given, in this high death-rate, as to whether patients died from shock, amputations, etc. In Guy's Hospital, from 1841-1861, there were reported 208 cases of compound fractures, with 56 deaths, thus giving a mortality of about 26 per cent. In other words, it is shown by these figures approximately that, before the introduction of antiseptics into hospital practice in the treatment of compound fractures, that the rate of mortality in the best tables varies from 20 to 60 per cent.

If now some statistics are examined after the introduction of antiseptics, with a view to ascertain their influence upon the rate of mortality, one is at once confronted with an astonishing fact. If, for example, Billroth's table is referred to after the use of antiseptics, the death-rate is reduced to one-tenth of what it had been formerly in the treatment of compound fractures. The influence, therefore, of antiseptics has caused the death-rate to fall from twenty to sixty per cent. to about four per cent. within a period of a few years.

In the present report of 516 cases of compound fractures, if we compare the fractures of the *extremities* only, as has been the case in the above tables, there is no death from septo-pyæmia, and thus the rate of mortality from blood-poisoning is now reduced from sixty per cent. to a figure which is represented by a cipher. It may be said, therefore, that pyæmia and septicæmia, which destroyed as many as sixty per cent. of human lives in cases of compound fractures, have been practically eliminated as causes of death.

The science of surgery has at last demonstrated to the world that it has fairly met this demon of destruction, and conquered him; and, in conclusion, in referring to this great reduction in mortality, an inquiry is not inappropriate as to the means which has brought it about, and also as to the special influence to which it is due. Without doubt, the science of bacteriology has largely contributed to this object, and this building in which we are now convened, with its spacious laboratories devoted to this study, attests the importance in which this work is held, and also without doubt the one to whom the profession is indebted for the practical application of this science is Sir Joseph Lister, whose name can never be disassociated with the march and progress of surgery.

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